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Entrepreneurship Capital and Technical Efficiency

The Role of New Business/Firms as a Conduit of Knowledge Spillovers

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Abstract

Increasingly, entrepreneurship is being discussed and considered as a source of high economic growth and competitiveness. A conceptual process of creative construction that characterizes the dynamics between entrants and incumbents can prove quite useful to analyze the impact of countries' entrepreneurship capital on economic performance and can be a guide for economic policy.

This paper applies a Stochastic Frontier Analysis approach to test the hypothesis that entrepreneurship capital promotes economic performance by serving as a conduit of knowledge spillovers. In addition, kernel density functions are employed to analyze convergence (or divergence) in the efficiency estimated for individual countries.

The empirical evidence and results here tend to support the hypothesis. Specifically, the empirical analysis shows that the rate of expenditure on research and development in relation to new businesses registered has a positive and significant effect in increasing technical efficiency. These factors facilitate the dissemination of existing knowledge, develop entrepreneurship capital, and thus provide the missing link to economic performance—entrepreneurship capital. The authors also show the trends and dynamics of changes in countries' technical efficiency.

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Entrepreneurship Capital and Technical Efficiency:
The role of new business/firms as a conduit of knowledge spillovers[1]

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1.- Introduction

The knowledge-based view of the firm argues that wealth creation in a firm is a function of its ability to create new knowledge and to exploit it in the market (Teece, Pisano and Schuen, 1997). However, the investment that a firm makes in knowledge-related activities has important implications beyond its boundaries because of its lack of ability to appropriate and exploitat all the benefits. As a result, existing organizations may be characterized as having an abundance of underexploited knowledge (Agarwal et al., 2004).

For Agarwal, Audretsch and Sarkar (2010), individuals that perceive unexploited opportunities created by knowledge investments by incumbent organizations, may choose to venture out using the human capital/knowledge they acquired during their tenure at the knowledge-generating organization. Entrepreneurs starting a new venture not only create new firms, but also provide a conduit for the spillover of knowledge that might otherwise not have been commercialized and would have remained dormant in the incumbent firm.

The literature that links knowledge spillovers to entrepreneurship capital emphasizes that existing (incumbent) organizations are an important source of new entrants, as they embody knowledge that can be appropriated, and thus facilitate new entry into the sector (Audretsch, 1995; Agarwal, et al., 2004; Colombo, 2005).

The knowledge spillover theory of entrepreneurship suggests that knowledge spillovers serve as the source and create the entrepreneurial opportunities for new firms. This theory suggests that entrepreneurship is the missing link in the process of economic growth because it facilitates the spillover of knowledge from universities and private firms, resulting in commercialization of ideas that otherwise might remain unexploited or uncommercialized.[2]

According to Audretsch and Keilbach (2003), by starting up a business, an entrepreneur literally “bet” on the product he offers and thus is willing to take the risk that this venture bears. Acs and Audretsch (2003) observe that, “by commercializing ideas that otherwise would not be pursued and commercialized, entrepreneurship serve as one mechanism facilitating the spillover of knowledge.”

The empirical evidence supporting the knowledge-spillover theory of entrepreneurship is based on the analysis of variations in startup rates across different industries reflecting different underlying knowledge contexts. As pointed out by Caves (1998), those industries with a greater investment in new knowledge also exhibited higher startup rates, while those industries with less

[2] “Although characteristics of entrepreneurial activity differ across countries, the importance of entrepreneurship for economic development is widely acknowledged” (Global Entrepreneurship Monitor (GEM) 2007 Executive report (2008: 12))

investment in new knowledge exhibited a lower startup rate, where startups are interpreted as a conduit, transmitting knowledge spillovers.[3]

Agarwal, Audretsch and Sarkar (2010) deal with these questions by developing the creative construction approach, which identifies knowledge spillovers as a key mechanism that underlies new firms' formation and development at the micro level, and economic performance at the macro level.

Yet little analytical, and particularly empirical, work has been undertaken to support that general hypothesis. Here we are advancing the knowledge on this subject by analyzing the impact of countries' entrepreneurship capital on economic performance. The main objective of this work is to analyze whether the entrepreneurship capital promotes economic performance (in terms of technical efficiency) by serving as conduit of knowledge spillovers.

With this objective in mind, the work is organized as follows: in the next section we present the conceptual framework proposed to clarify the relation between new business (as a conduit of knowledge spillovers) and economic performance (in terms of technical efficiency). In Section 3 we develop the methodology of the analysis. In Section 4 we present the main empirical results. Section 5 ends with a summary of the main conclusions and policy implications.

2. Background: Creative Construction and Economic Performance

2.1. The Process of Creative Construction

Agarwal, Audretsch and Sarkar (2010) argue that creative construction is similar to creative destruction in highlighting the creation of value through entrepreneurial entry. However, it differs from creative destruction in two aspects: (i) it identifies the "construction" of these new entrants due to incumbent investments in knowledge, and (ii) it questions whether incumbents are necessarily destroyed in the process, given the potential for simultaneous (co-existent) growth of both incumbents and entrants alike, and for strategic management by incumbents of the knowledge spillovers that may result in "spill-ins".

In addition, Agarwal and Bayus (2002) show that sales and growth in the industry are linked to a critical mass of entry in the industry. Other authors like Saxenian (1994) have explicitly linked the growth of regions and industries to spinout/spinoff activity. These authors document the positive synergies and agglomeration economies caused due to geographical clusters enabled by knowledge spillover, strategic entrepreneurship, and they also provide several reasons for a win-win rather than a win-lose outcome.

[3] In relation with this issue, and in order to evaluate a potential reverse causality concern in our analysis, we perform a Granger causality test (see more details in Section 4).

The first reason stems from agglomeration and legitimacy effects, which can lead to increase in demand that permits simultaneous growth of both the parent and the progeny. Klepper (2007) argues that growing industries and regions attract not only additional human capital, but also supporting infrastructure related to the supply-chain operations needs as well as venture financing. Not only does this serve to reinforce the supply-side effects for the incumbent organization, but it can also lead to enhanced demand of the product it sells. Thus, particularly in the growth stages of the industries, both parent and progeny organizations may grow, and the growth of one is not at the expense of the other.

The second reason stems from "spill-in" or capability enhancement effects which arise when spinouts occupy complementary rather than competitive positions, and their growth in capabilities provides a potential for learning (and even subsequent acquisition of the spinout firm) by the parent organization.

According to Somaya, Williamson and Lorinkova (2007), an incumbent firm may be able to leverage off the capabilities of the spinout it has spawned, and use it as a complementary asset. While much has been documented about spinouts occupying competing positions in the supply chain, the authors have systematically documented that employee mobility to firms that are vertically linked, or produce complementary products, can have beneficial effects on the incumbent firms.

Finally, Somaya, Williamson and Lorinkova (2007) argue that an incumbent can access new knowledge, competencies and capabilities created in the new venture, by relying on social capital links to the new venture. Such linkages, either formally through contractual agreements, or informally through interactions of personnel from both the incumbent and new venture, can facilitate the access of valuable know-how and competencies generated by the new venture, thereby enabling the "spill-in" of knowledge from the new venture generated by the spillover back to the incumbent.

2.2. Economic Performance

The dynamics at the firm level also have implications at macro levels on the performance of regions, industries and economies. As endogenous growth theory (Romer, 1990) suggests, a greater degree of knowledge spillovers will spur higher rates of growth, employment and international competitiveness.

Entrepreneurial new ventures are an important mechanism for knowledge spillovers, as their use of knowledge and ideas serves as the crucial resource driving the competitive advantage of the industries, regions and economies that they are associated with. Regions and industries with a high degree of entrepreneurial activity will also facilitate more knowledge spillovers, which, in turn, will increase economic growth, employment creation, economic performance and international competitiveness. Thus the virtuous cycle.

In others words, endogenous-growth models improve on the earlier traditional models of growth by providing insights regarding the underlying growth-transmission mechanisms, and, focusing on economic performance as being driven by explicit firm action, either due to investments in knowledge by existing organizations, or due to research activity undertaken by new entrants. These models advance our understanding of the underlying mechanisms by relating growth to exogenous spillovers of endogenous investments in knowledge. However, this approach assumes that spillovers are randomly generated.

As we show in the next section, our conceptualization highlights the active role of entrepreneurial action in the spillover process; thus, in addition to endogenous investments in knowledge by incumbent organizations, spillovers occur due to subsequent endogenous pursuit of innovation by individuals immersed in these institutional contexts. As a result, economic performance is due to deliberate investment and activity both by incumbent organizations, and by entrepreneurial individuals within these organizations who then carry it over to new entities through the creation of new ventures.

Entrepreneurship is an important conduit of knowledge spillovers, In its absence, that existing knowledge might not have been commercialized, so that there would have been no growth emanating from the investments in knowledge made by incumbent organizations. Importantly, such a conceptualization draws attention to the fact that economic performance occurs due to path-dependent action that is local or non-random in nature.

3. Methodology: Empirical Model, Dynamic Convergence, Data and Variables

According to economic theory (Leibenstein, 1968), an enterprise can be categorized as technically efficient if it is able to produce maximum output given available resources. According to the literature, a gap normally exists between a firm's actual and potential (feasible) levels of economic performance.

Efficiency will be defined herein as the activity which produces maximum production given a certain set of resources, alternatively, the action which consumes the least possible volume of resources in order to achieve a certain volume of production. There are three different efficiency categories to consider: scale, assigned or technical, but this paper focuses on technical efficiency which measures total production volume produced with allocated (given) resources.

In this context, Farrell (1957) proposed that the efficiency of a firm consists of two components: technical efficiency, which reflects the ability of a firm to obtain maximal output from a given set of inputs, and allocative efficiency, which reflects the ability of a firm to use the inputs in optimal proportions, given their respective prices and the production technology.

Although there is no consensus among researchers regarding the way to establish the process to evaluate the influence of capital entrepreneurship variables on technical efficiency levels, in this paper we have attempted to detect/link the repercussion of certain intermediate factors – like R&D activity - by using deterministic frontier production functions. In this context, a Stochastic Frontier Analysis (SFA) approach is applied to estimate technical efficiency rates for individual countries. In addition, kernel density functions are employed to analyze convergence (or divergence) in the efficiency estimated.

SFA estimates an efficient frontier incorporating the possibility of measurement error or chance factors in its estimation. To separate inefficiency and noise, strong assumptions are needed on the distribution of noise among each observed firm.

A production frontier reveals technical relationships between inputs and outputs of firms and represents an alternative when cost frontiers cannot be calculated due to lack of data. The estimated output is the maximum possible output for given inputs of an individual firm. The output difference obtained in the estimation is interpreted as technical inefficiency of each individual country.

3.1. Empirical Model

Following to Coelli et al. (2005), a production function expresses one output as function of inputs. Mathematically, all these different functions can be written in the form: $y = f(x_1, x_2, ..., x_N)$, where y is the dependent variable; the $x_n(n = 1,..., N)$ are the explanatory variables; and $f(\cdot)$ is a mathematical function. In this context, the first step in estimating the relationship between the dependent and explanatory variable is to specify the algebraic form of $f(\cdot)$.

In this study we use specifications such as the Cobb-Douglas (CD) function with constant returns to scale and the TransLog (TL) with variable elasticity of factor input substitution. Also we account for technological change by including a time trend as suggested by Coelli et al. (2005). The next expressions (1) (for CD specification) and (2) (for TL specification) account for technological change:

$$\ln y = A_0 + \theta t + \sum_{n=1}^{N} \beta_n \ln x_n \quad (1)$$

$$\ln y = \beta_0 + \theta_1 t + \theta_2 t^2 + \sum_{n=1}^{N} \beta_n \ln x_n + \frac{1}{2} \sum_{n=1}^{N} \sum_{m=1}^{N} \beta_{nm} \ln x_n \ln x_m \quad (2)$$

In (1) and (2), t is a time trend; and θ, θ_1 and θ_2 are unknown parameters to be estimated. Including time trends in the previous models makes implicit assumptions about the nature of technological change. Following to Coelli et al. (2005), the CD specification implicitly assumes that technological change is constant related to *y*; the TL model allows the technological change effect to increase or decrease with time (depending on whether θ_2 is positive or negative). The percentage change in *y* in each period due to technological change is given by the derivate of ln *y* with respect to *t* in (1) and (2).

Continuing with Coelli et al. (2005), one method for estimating a production frontier using data is to envelop the data points using an arbitrary-chosen function.

In basic stochastic production frontier models, the output is specified as a function of a non-negative random error which represents technical inefficiency, and a symmetric random error which accounts for noise. Aigner, Lovell and Schmidt (1977) and Meeusen and van den Broeck (1977) proposed the stochastic production frontier model of the form:

$$\ln q_i = \mathrm{x}_i^{'} \beta + v_i - u_i \quad (3)$$

In (3), q_i represents the output of the i-th firm; x_i is a $K \times 1$ vector containing the logarithms of inputs; β is a vector unknown parameters; v_i is a symmetric random error to account for statistical noise; and u_i is a non-negative random variable associated with technical inefficiency. The resulting function is called stochastic production frontier because the output values are bounded from above by the stochastic variable $\exp\left(\mathrm{x}_i^{'} \beta + v_i\right)$. The random error v_i can be positive or negative and so the stochastic frontier outputs vary about the deterministic part of the model, $\exp\left(\mathrm{x}_i^{'} \beta\right)$. In the case of firms that produce the output q_i using one input, x_i, the CD stochastic frontier model take the form:

$$q_i = \exp(\beta_0 + \beta_1 \ln x_i + v_i - u_i) \quad (4)$$

The most common output-oriented measure of technical efficiency is the ratio of observed output to the corresponding stochastic frontier output:

$$TE_i = \frac{q_i}{\exp\left(x_i^{'}\beta + v_i\right)} = \frac{\exp\left(x_i^{'}\beta + v_i - u_i\right)}{\exp\left(x_i^{'}\beta + v_i\right)} = \exp(-u_i) \quad (5)$$

It measures the output of the i-th firm relative to the output that could be produced by a fully-efficient firm, using the same input vector. According to Coelli et al.(2005), panel data often allows us: i) to relax some of the strong distributional assumptions that were necessary to disentangle the separate effects of inefficiency and noise, ii) to obtain consistent predictions of technical efficiencies, and iii) to investigate changes in technical efficiencies over time. Panel data versions (Aigner, Lovell and Schmidt (1977) and Meeusen and van den Broeck (1977)) can be written in the general form:

$$\ln q_{it} = x_{it}^{'}\beta + v_{it} - u_{it} \quad (6)$$

The expression (6) is identical to the model (4) except we have added a subscript "t" to represent time. The expectation is that inefficient firms improve their efficiency levels over time, with managers learning from experience, and for their technical efficiency levels to change systematically over time.

One model (Battese and Coelli 1993) allows for time-varying technical inefficiency and takes the form: $u_{it} = f(t) \cdot u_t$, where $f(.)$ is a function that determines how technical inefficiency varies time:

$$f(t) = \exp[\eta(\mathrm{t} - \mathrm{T})] \quad (7)$$

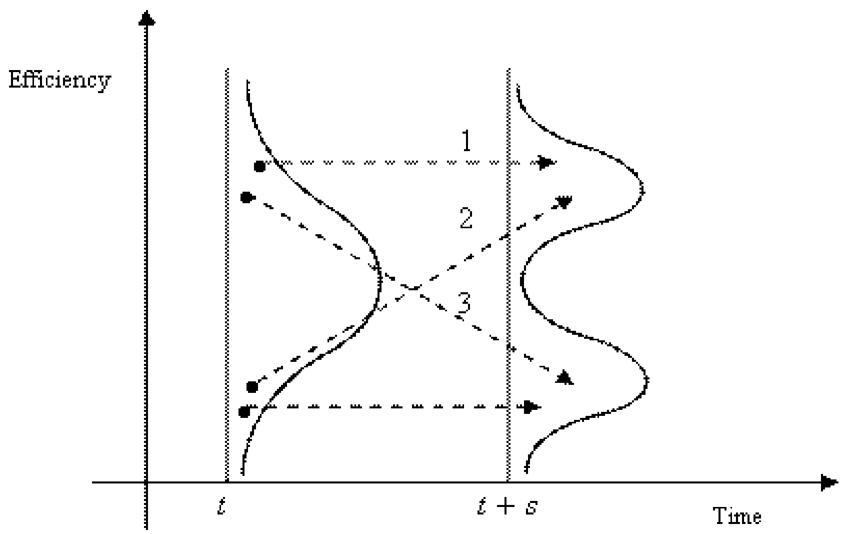
In (7), η is unknown parameter to be estimated. The Battese and Coelli (1993) function has the properties $f(t) \geq 0$ and $f(T) = 1$, and is either non-increasing or non-decreasing depending on the sign of η. However, it is convex for all values of η. The Battese and Coelli (1993) model can be estimated under the assumption that u_i has a truncated normal distribution: $u_i \sim iddN^{+}\left(\mu, \sigma_u^2\right)$.

3.2 . The Efficiency Distribution Dynamic

To understand the dynamic of the whole efficiency distribution, the intention is to use stochastic kernel estimators in much the same way as Birchenal and Murcia (1997) employed them to analyse convergence.

Figure 1 illustrates this approach, showing a possible distribution of efficiency in two time periods, *t* and *t+s*. The distribution in period *t* indicates that there is an average efficiency level shared by most of the economies considered, and that there are few with extremely high or low efficiency. By contrast, *t+s* groups the most and least efficient economies to create two clearly differentiated groups, while the medium-efficiency groups have disappeared.

Figure 1. Change in the efficiency distribution



Source: Prepared on the basis of Birchenal and Murcia (1997).

The arrows in Figure 1 show the internal dynamic of the distribution. For example, arrows 2 and 3 indicate the “mobility” of the economies within the distribution, and arrows 1 and 4 indicate the “persistence” of the economies that keep their original position between periods *t* and *t+s*.

To analyse this dynamic without distorting it, the idea is to divide the efficiency space into an infinite number of regions or a continuum. In this case, the corresponding transition probability matrix will tend towards a continuum of rows and columns, becoming a stochastic kernel.

3.2. Data and Variables

Table 1 presents a summary of the key variables used to empirically validate the combined stochastic-inefficiency model for 61 countries from 2002 to 2005.

Table 1. Function production variables

Variables	Definition
Y_{NTx1}: GDP[1] (constant 2000 US$)	GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in constant 2000 U.S. dollars. Dollar figures for GDP are converted from domestic currencies using 2000 official exchange rates. For a few countries where the official exchange rate does not reflect the rate effectively applied to actual foreign exchange transactions, an alternative conversion factor is used.
K_{NTx1}: Gross fixed capital formation[2] (constant 2000 US$)	Gross fixed-capital formation (formerly gross domestic-fixed investment) includes land improvements (fences, ditches, drains, and so on); plant, machinery, and equipment purchases; and the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings. According to the 1993 SNA, net acquisitions of valuables are also considered capital formation. Data are in constant 2000 U.S. dollars.
L_{NTx1}: Labor force,[3] total	Total labor force is comprised of people who meet the International Labor Organization definition of the economically active population: all people who supply labor for the production of goods and services during a specified period. It includes both the employed and the unemployed. While national practices vary in the treatment of such groups as the armed forces and seasonal or part-time workers, in general the labor force includes the armed forces, the unemployed and first-time job-seekers, but excludes homemakers and other unpaid caregivers and workers in the informal sector.
T_{NTx1}: Time	Cyclical and Hicks neutral technological progress.
$R\&D_{NTx1}$: Research and development expenditure[4]	Expenditures for research and development are current and capital expenditures (both public and private) on creative work undertaken systematically to increase knowledge, including knowledge of humanity, culture, and society, and the use of knowledge for new applications. R&D covers basic research, applied research, and experimental development.
NBR_{NT}: New Businesses Registered[5]	New businesses registered are the number of new firms, defined as firms registered in the current year of reporting.
T_{NTx1}: Year	Time-varying inefficiency effect.

Notes:
[1]International Finance Corporation's micro, small, and medium-size enterprises database (http://www.ifc.org/ifcext/sme.nsf/Content/Resources).
[2]World Bank national accounts data, and OECD National Accounts data files.
[3]International Labour Organization, using World Bank population estimates.
[4]United Nations Educational, Scientific, and Cultural Organization (UNESCO) Institute for Statistics.
[5]International Finance Corporation's micro, small, and medium-size enterprises database (http://www.ifc.org/ifcext/sme.nsf/Content/Resources).
Source: World Bank's World Development Indicators (2009), and authors' calculations.

The data source used for this analysis is the World Bank's World Development Indicators (WDI). This database provides more than 800 development indicators, with a time series for 209 countries and 18 country groups from 1960 to 2007. From the World Bank's World Development Indicators (WDI), we have time series observations (T=4) for 2002, 2003, 2004 and 2005. We are able to form a balanced panel data, as seen in the descriptive statistics of variables in Table 2.

Table 2. Descriptive statistics of variables of the production frontier model 2002-2005

Variable	Year	Mean	Std. Dev.	Min	Max
GDP (in millions)	2002	456684	1419363	9997600	2371
	2003	466695	1451176	10249800	2703
	2004	483326	1503767	10651700	2987
	2005	497255	1547630	10995800	3402
Gross Fixed Capital Formation (GFKF) (in millions	2002	91219	274765	1835000	448
	2003	93539	280281	1890700	600
	2004	98363	293680	2004600	637
	2005	103604	309418	2132800	664
Labor Force (LF) (in miles)	2002	20738	55685	408342	168
	2003	21005	56640	416285	169
	2004	21353	57546	422759	173
	2005	21656	58537	430607	177
Research and Development Expenditure (R&D) (in miles)	2002	10336237	38943279	265884666	215
	2003	10553995	39853975	272239510	354
	2004	10714079	40311619	275048835	988
	2005	11210290	42355334	287770196	1168
New Businesses Registered (NBR)	2002	49496	101292	650843	31
	2003	52404	104156	618503	57
	2004	57433	111332	657195	24
	2005	59459	114565	676830	23

Notes:
Number of observations = 61 countries.
Source: Authors' calculation from the World Bank's World Development Indicators (WDI).

4.- Empirical Results

There is a wide difference and variation of expenditure on Research and Development – R&D (as a percentage of GDP) across countries (see Appendix tables 6 and 7). There are also differences on New Business Entry Rate – NBER (New Businesses Registered - NBR as % of total business) across countries when grouped in terms of High-Medium and Medium-Low-Tech (see Table 3).

Some examples are Sweden[4] (high expenditure on R&D and low NBER), Turkey[5] (high NBER and low expenditure on R&D), India[6] (low expenditure on

[4] The industrial sector plays an important role in Sweden's economy. Recently the Agricultural sector has also contributed a lot to the country's Gross Domestic Product. The major industries in the country are iron, steel, wood pulp, paper products, and motor vehicles. The important agricultural products in the country are wheat, barley, sugar and milk.

[5] In the case of Turkey the strong and rapidly growing private sector is a landmark of its economic success.

[6] Agriculture is a major component of India's economy. The industrial sector includes manufacturing industries, textiles and handicrafts, etc. However, the service sector is greatly expanding and has started to assume an increasingly important role (e.g., India has become a hub

R&D and low NBER) and Germany[7] (high expenditure on R&D and high NBER).

Table 3. Average of variables of production frontier model 2002-2005 by technological level

Sample	GDP	GFKF	LF	R&D		Entrepreneurship capital	
2002-2005	Total	Total	Total	Total	% GDP	NBR	NBER
All	475990	96681	21188	10703.65	1.49	54698	8.83
High-Medium Tech countries[1]	996684	199474	19562	24907.70	2.82	91304	9.91
Medium-Low-Tech countries[2]	114397	25298	22317	839.73	0.565	29277	8.07

Notes:
[1] High-Medium Tech countries: R&D (% GDP) > 1 (year 2002)
[2] Medium-Low-Tech countries : R&D (% GDP) < 1 (year 2002)
Source: Authors' calculation from the World Bank's World Development Indicators (WDI).

With a medium level on R&D and NBER, Italy has an robust small and medium enterprise sector (77.8% of total firms), but it has not been as successful in establishing multinational corporations[8] .

4.1. Efficiency and Productivity Analysis

When comparing efficiency levels, we can see large differences between countries (see Appendix Tables I and II). The above differences are greater when comparing High-Medium and Medium-Low-Tech countries (see Table 4).

Using a TransLog production function to estimate Technical Efficiency, we observe important differences across countries (see Appendix Tables I and II). We can see that the U.S. has a high level of technical efficiency while Bolivia has a very low level of technical efficiency, and can/should significantly improve its performance, making better use of its resources. In between we have the cases of Japan,[9] United Kingdom[10] and Canada[11] (high efficiency), Georgia,[12],Mexico[13]

of outsourcing activities in the areas of technical support and customer services for some of the major economies of the world).

[7] In Germany's economy, the average annual growth rate of GDP has been on a decline since the 1980s. Germany's economy is currently recovering, ending a phase in stagnation on the back of its traditionally strong, competitive and innovative export-oriented manufacturing sector.

[8] Many of these companies do not have a high level of technology sophistication. Italian services today make up 69% of the economy, industry 29%, and agriculture 2%.

[9] Japan's economy is the second largest economy in the world and the largest in Asia, based on real GDP, market exchange rates, and nominal GDP. Japan uses planned development of science and technology, and has a strong work culture. However, in the 1990s Japan experienced a "Lost Decade", a period when the Japanese economy was stagnant.

[10] The main economic activity of United Kingdom is the service sector (76.2% of GDP in 2008). Industry and manufacturing (22.8%) and agriculture (0.9%) are other important industrial sectors.

and New Zealand[14] (medium efficiency) and Iceland[15] (low efficiency). There are determinants of the ranking and there are some plausible explanations in the corresponding footnotes.

Table 4. Estimates of Technical Efficiency, Marginal effects, and inefficiency

Function	**TransLog (TL)**			**Cobb-Douglass (CB)**		
Mean 2002-2005	**Efficiency**	**Marginal Effects**	**Inefficiency E(u/e)**	**Efficiency**	**Marginal Effects**	**Inefficiency E(u/e)**
All sample	0.937	0.068	0.068	0.991	0.011	0.011
High-Medium Tech countries[1]	0.953	-0.824	0.049	1.000	-0.872	0.000
Medium-Low-Tech countries[2]	0.926	0.688	0.082	0.985	0.624	0.018

Notes:
[1] High-Medium Tech countries: R&D (% GDP) > 1 (year 2002)
[2] Medium-Low-Tech countries : R&D (% GDP) < 1 (year 2002)
Source: Authors' calculation from the World Bank's World Development Indicators (WDI).

United Kingdom's economy has a large trade deficit in manufacturing and has become a net importer of energy.

[11] Canada has moved from agriculture straight to services (this industry is very diverse and employs 75% of the total million working population). Manufacturing has never been a dominant sector of the Canadian economy, but it has been an important secondary industry.

[12] The main economic activity of Georgia is agriculture. Mining, construction, financial services and communication are other sector making significant contribution towards Georgia's GDP. Georgia has a good supply of hydropower, however it imports a major part of its energy resources.

[13] Mexico has one of the largest economies in the world. The industrial sector in Mexico is very heterogeneous (the industrial sector combines technologically advanced businesses and antiquated industries). The agricultural sector is also an important part of the Mexican economy. The private sector has started assuming an increasingly important role in both the agricultural and the industrial sectors.

[14] Manufacturing and creative media largely constitute the New Zealand economy. Some of the major industries of New Zealand include iron and steel, natural gas processing, printing, publishing and recorded media, wood processing, cement, and fishing. Other minor industries in New Zealand include paper, tanning, transport equipments, wine making, tourism, and timber trade. Manufacturing industries in New Zealand contribute over 15% of GDP and over 44% of export receipts. Agriculture also contributes significantly to the economic growth of New Zealand.

[15] Iceland has a Scandinavian-type economy. This means that the main economic activity of Iceland is the fishing industry. Iceland also exports animal products and aluminum. New businesses in Iceland are tourism, software production, financial services and biotechnology.

Table 5. Maximun Likelihood Estimates (MLE): Cobb-Douglass (CD) and TransLog (TL) Stochastic Production Frontier Model

Model	Function Variable[1]/Technological level	TransLog (TL) All	TransLog (TL) Medium-Low-Tech	TransLog (TL) High-Medium Tech	Cobb-Douglass (CD) All	Cobb-Douglass (CD) Medium-Low-Tech	Cobb-Douglass (CD) High-Medium Tech
Dep. Var.	GDP	Const../ Std. Err.	Const./ Std. Err.	Const./ Std. Err.	Const./ Std. Err.	Const./ Std. Err.	Const./ Std. Err.
Prod. Frontier	Constant	0.079*	0.055*	0.154***	0.011	0.141	3.97E-02
		[0.048]	[0.033]	[0.041]	[0.013]	[0.104]	[0.039]
	K_t	1.007***	0.975***	0.928***	0.991***	0.936***	9.85E-01***
		[0.013]	[0.022]	[0.023]	[0.010]	[0.032]	[0.025]
	L_t	0.038***	0.133***	0.078**	0.043***	0.104***	0.025
		[0.014]	[0.027]	[0.032]	[0.012]	[0.020]	[0.034]
	T_t	-0.059***	-0.043**	-0.019	-0.026**	-0.054	-0.029
		[0.0203]	[0.0203]	[0.021]	[0.011]	[0.035]	[0.023]
	K_t^2	-0.043***	0.005	-0.120***	-	-	-
		[0.016]	[0.025]	[0.037]			
	$K_t \cdot L_t$	0.043***	0.026	0.108***	-	-	-
		[0.016]	[0.026]	[0.039]			
	$K_t \cdot T_t$	-0.009	-0.021	0.009	-	-	-
		[0.009]	[0.015]	[0.013]			
	$L_t \cdot T_t$	0.000	0.003	-0.017	-	-	-
		[0.011]	[0.015]	[0.014]			
	L_t^2	-0.028	0.033	-0.117***	-	-	-
		[0.018]	[0.031]	[0.035]			
	T_t^2	0.021	0.013	-0.002	-	-	-
		[0.029]	[0.033]	[0.025]			
u_{it}	constant	-5.665***	-9.836***	-8.930***	-63.278*	-4.689	-1.01E+01**
		[1.803]	[2.733]	[2.210]	[32.711]	[3.487]	[4.893]
	$R\&D_t$	0.248	3.420**	-4.304***	11.164	0.415	-3.61E+00*
		[0.398]	[1.473]	[1.327]	[7.598]	[0.952]	[2.001]
	NBR_t	0.265	1.477	1.113	3.236	-0.385	1.52E+00
		[0.400]	[1.009]	[1.264]	[9.564]	[0.878]	[1.567]
	T_t	-1.081	-1.088	-0.091	-0.338	-0.609	7.55E-03
		[0.675]	[0.901]	[0.991]	[1.287]	[1.774]	[1.665]
	$R\&D_t^2$	0.061	-0.468	-1.540***	0.299	-0.118	-1.02E+00
		[0.138]	[0.362]	[0.564]	[0.907]	[0.293]	[0.681]
	NBR_t^2	0.420	0.416	0.007	13.744	-0.109	0.926
		[0.489]	[0.424]	[0.701]	[11.211]	[0.414]	[1.249]
	$R\&D_t \cdot NBR_t$	-0.078	-0.830	0.345	-1.534*	0.027	9.57E-02
		[0.074]	[0.524]	[0.602]	[0.909]	[0.387]	[0.880]
	$R\&D_t.T_t$	-	0.161	0.038	-	-0.030	1.05E-01
			[0.272]	[0.363]		[0.509]	[0.496]
	$NBR_t.T_t$	-	-0.055	-0.085	-	-0.183	-1.01E-01
			[0.282]	[0.276]		[0.649]	[0.394]
v_{it}	constant	-3.426***	-3.524***	-4.627***	-3.319***	-3.154***	-4.11E+00***
		[0.125]	[0.158]	[0.252]	[0.092]	[0.200]	[0.169]
	Sigma-squared	0.180	0.172	0.099	0.190	0.207	1.28E-01
		[0.011]	[0.013]	[0.012]	[0.009]	[0.0207]	[0.011]
Wald chi2		15408.11	4980.84	21248.55	19794.51	1728.23	7729.43
Prob > chi2		0.000	0.000	0.000	0.000	0.000	0.000
Log likelihood		57.275	27.675	71.755	56.894	15.317	59.712
Number of obs		244	144	100	244	144	100

[1]Description in natural logs.

Source: Authors' calculation from the World Bank's World Development Indicators (WDI).

When we consider all countries, Table 5 shows that the combined effect of R&D expenditure and New Businesses Registered (NBR) has a positive and significant effect to reduce the Technical inefficiency (in the Cobb-Douglass specification).

We observe a very different behavior between countries with Medium-Low-Tech level and countries with High-Medium Tech level (using a TransLog production function). In countries with High-Medium Tech level, the R&D expenses have a positive and significant effect on technical efficiency (in the short and long term). In contrast, in countries with Medium-Low Tech level, the R&D expenses have a negative and significant effect on technical efficiency (in the short term).

When we use a Cobb-Douglass production function, in countries with High-Medium Tech level, the R&D expenses have a positive and significant effect on technical efficiency (only in the short term).

Finally, since earlier GEM reports demonstrated a systematic, U-shaped relationship between a country's level of economic development and its level and type of entrepreneurial activity, there might be a potential reverse-causality issue. To address this issue, in applying a second step SFA procedure, we performed the Granger causality test which showed a statistically significant positive value of the Wald test on all coefficients of distributed lags[16] but only in the TransLog specification.

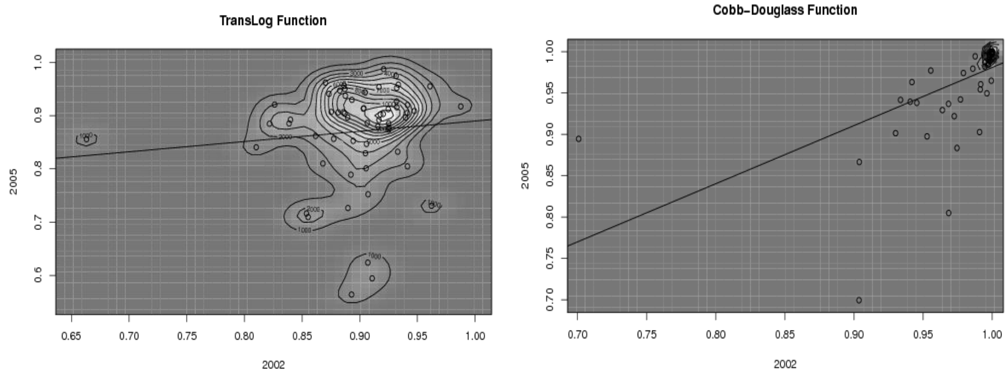
4.2. Efficiency and Dynamic Convergence Analysis

The issue here is to analyze the trend and dynamics of the distribution of technical efficiency, along the lines suggested by Quah (1993, 1997), that is, changes in the form of the distribution and distributional dynamic within that distribution,[17] based on the estimation of kernel density functions as proposed by Lucy, Aykroyd and Pollard (2002). The results are shown in Figure 2 and illustrate the trends in convergence (divergence) and persistence (mobility) in the level of technical efficiency attained by the countries during the period 2002-2005.

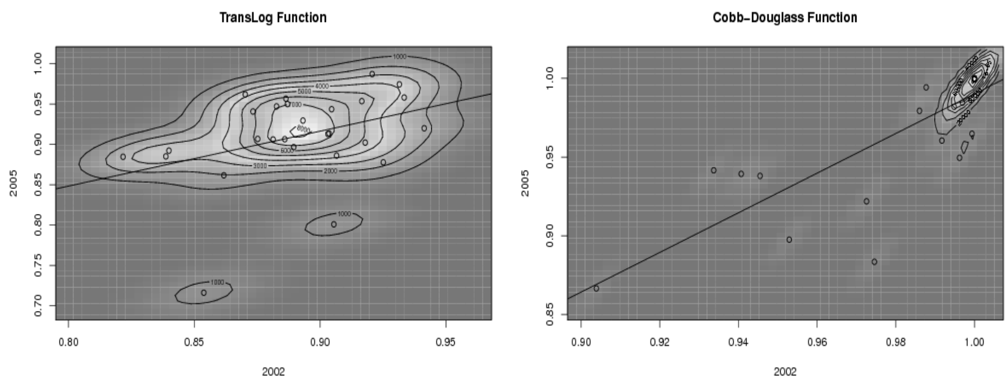
[16]The ratio between R&D expenses and the annual number of new firms - in the first OLS regression - and a non- statistically significant value of the Wald test on all coefficients of distributed lags of country's technical efficiency - in the second OLS regression.

[17] Quah (1997) argues that convergence coalitions, or clubs, can form endogenously across all countries, and the different convergence dynamics will depend on the initial distribution of country characteristics.

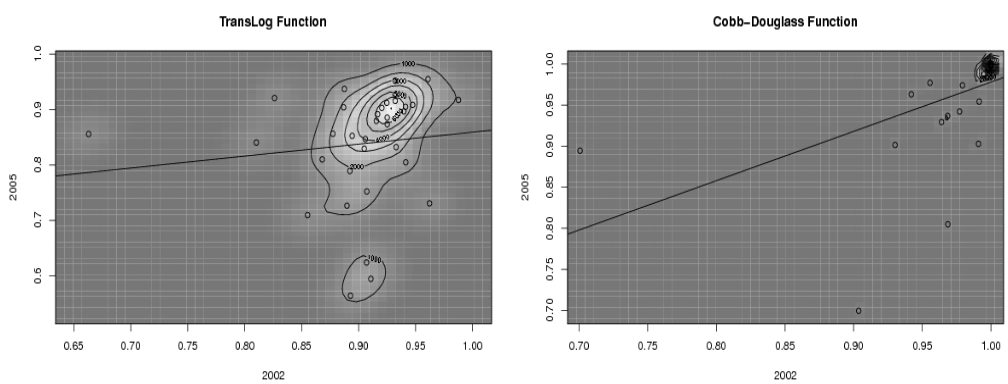
Figure 2. Bivariate Kernel Density



(a) Total sample



(b) High-Medium Tech countries



(c) Medium-Low-Tech countries

Source: Authors' calculation.

The interpretation of the graphs is as follows. If the whole distribution maintains its characteristics between periods t and t+s, we say the distribution of technical efficiency is *persistent*, that is, efficient countries remain efficient and inefficient ones remain inefficient. For the distribution of technical efficiency to show *mobility*, it would have to show a complete (at the extreme) reversal of the countries' starting conditions, so that those deemed inefficient in period t would become efficient in period t+s, while those deemed efficient would become inefficient.[18] Lastly, if the distribution clusters around a plane parallel to the t axis over time, whereas efficiency was distributed normally in the whole of the cross-section to begin with (i.e., with grouping around the value t+s=1), the distribution is said to be *converging on equality* in the countries' efficiency levels.

Focusing on TL specification for the entire sample (the variance in efficiency index is bigger than CD specification), what seems to come out from the data is a pattern of non-mobility regarding the efficiency level attained over the years, with a degree of convergence upon higher efficiency levels (this is reflected in the decreasing proximity of the dots marking out the different level curves to the axis drawn across the graphs).

For the High-Medium Tech countries technical efficiency over the whole period, we detect a pattern of divergence and mobility. And for the Medium-Low-Tech countries technical efficiency index over the whole period, we find a pattern of convergence and non-mobility with polarization towards higher technical efficiency values.

4. Conclusions and Policy Implications

We have shown the impact of R&D investments and entrepreneurship and of its interplay on economic performance. The results point to the positive effects of entrepreneurship on economic performance, and particularly when linked to R&D. Specifically, we have shown that the rate of R&D expenditures in relation to New Businesses Registered (NBR) has a positive and significant effect to reduce the technical inefficiency. Moreover, the dynamic analysis hints that, with the proper policies in those two areas, countries could, over time, significantly improve their economic performances as measured by technical efficiency.

The empirical results of this work indicate that not only the traditional factors associated with economic performance and growth are important, but in

[18] According to Birchenal and Murcia (1997), a simple way of appreciating these things is to observe whether the outlines of the distribution are concentrated on the 45 degree line marked on the *t–t+s* plane (in this case, the distribution persists during the periods). If the outlines of the distribution are concentrated on a line perpendicular to the 45 degree line, there is total mobility within the distribution.

addition, entrepreneurial activity also plays an important role in generating economic efficiency and in fostering a conducive environment for productivity, competitiveness and growth. In this context, the level of Expenses on R&D in relation to NBR plays a decisive role as a determinant of levels and change in technical efficiency.

Thus the policy implications are clear. In the context of the endogenous growth theory, the focus of public policy ought to shift towards policies and instruments that would increase investments in knowledge and in human capital, as well as research and development and facilitation for the formation of new firms and start ups.

Some of the specific policies that could be promoted would be:

- Developing and nurturing entrepreneurship and innovation through placing entrepreneurship modules in the curriculum of engineering and business schools;
- Celebrating innovation and entrepreneurship by establishing media programs and highly visible awards;
- Facilitating the creation of technology transfer offices at leading universities or through a consortia of universities;
- Implementing programs to facilitate and finance start-ups, particularly technology based;
- Fostering networks of incubators;
- Providing a coherent fiscal and financial incentives for R&D and for spin-offs;
- Inciting the development of supporting R&D infrastructure and networks of knowledge;
- Providing technological based training and knowledge transfer programs.

These actions should also be complemented by revising and simplifying procedures and costs for the registering of new firms, now still quite cumbersome and costly in many developing countries.

Authors like Suyanto, Salim and Bloch (2009) suggest that policies for strengthening the absorptive capacity of domestic entrepreneurship through investing in knowledge and human capital formation are critical and perhaps superior to those oriented at the development of entrepreneurship.

As far as issues for future research in these themes, rethinking and codifying what exactly constitutes entrepreneurship capital and how public policy can more effectively and directly contribute to its formation would be most useful. Another critical area would be to explore the linkages between the creation of entrepreneurial opportunities, their implementation through launching a new venture, and the subsequent impact on regional economic growth and development. Such analysis would help to quantify the overall performance consequences and social welfare gains of knowledge spillover through strategic entrepreneurship

Finally, on the econometric methodology for these type of analyses, it would be useful to use others' non-parametric approaches in order to evaluate how robust these findings are, since while the SFA accounts for data noise, such as data errors and omitted variables, the separation of noise and inefficiency relies on strong assumptions on the distribution of the error term.

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Appendix

Table 6 Basic statistic High-Medium Tech countries: Mean 2002-2005

Mean 2002-2005	GDP	GFKF	LF	RDTotal	RD % GDP	NBR	NBER	Efficiency TL	mfx TL	Inefficiency TL	Efficiency CD	mfx CD	Inefficiency CD
Australia	450718	117059	10106	7827.95	1.74	78448	9.00	0.969	-1.932	0.032	1	-1.94	0
Austria	202210	42790	3957	4550.24	2.25	13303	8.06	0.954	-0.884	0.048	1	-0.907	0
Belgium	243266	49457	4428	4592.78	1.89	23351	7.18	0.956	-1.036	0.046	1	-1.055	0
Canada	788585	163060	17316	15852.70	2.01	84052	6.07	0.967	-2.27	0.034	1	-2.293	0
Croatia	21827	6039	1959	241.04	1.11	7039	6.66	0.947	1.171	0.055	1	1.07	0
Czech Republic	63260	18320	5166	810.58	1.28	30945	11.31	0.961	-0.001	0.04	1	-0.078	0
Denmark	165430	33530	2860	4145.09	2.51	21918	10.24	0.955	-0.628	0.047	1	-0.65	0
France	1400735	272224	26919	30384.72	2.17	130423	11.20	0.973	-2.799	0.027	1	-2.823	0
Georgia	3865	1542	2316	8.19	0.21	3650	7.14	0.959	2.517	0.042	0.988	2.438	0.012
Germany	1937468	366735	40625	48390.03	2.50	73416	16.26	0.969	-3.098	0.032	1	-3.136	0
Iceland	9723	2224	172	277.61	2.86	2741	12.94	0.905	2.33	0.103	1	2.19	0
Ireland	115643	26987	1940	1388.19	1.20	15247	9.81	0.956	-0.398	0.046	1	-0.416	0
Italy	1128176	236345	24254	12483.23	1.11	102575	6.26	0.966	-2.654	0.036	1	-2.679	0
Japan	4826556	1117403	66943	155185.37	3.21	110958	4.34	0.984	-4.261	0.016	1	-4.261	0
Luxembourg	22418	4906	197	368.04	1.64	2199	11.27	0.886	1.434	0.127	1	1.367	0
Macedonia, FYR	3637	656	856	889.21	24.45	9713	6.70	0.918	3.424	0.09	1	3.299	0
Netherlands	399163	80179	8461	6989.90	1.75	98500	10.04	0.958	-1.538	0.043	1	-1.562	0
New Zealand	57919	13911	2105	685.08	1.18	55750	16.91	0.953	0.307	0.049	1	0.238	0
Norway	180168	32819	2482	2920.18	1.62	42073	14.66	0.951	-0.605	0.051	1	-0.621	0
Russian Federat.	317857	59584	73366	3753.84	1.19	372577	8.64	0.94	-1.266	0.064	1	-1.353	0
Slovenia	22101	5798	997	319.43	1.45	2698	7.49	0.927	1.236	0.079	1	1.134	0
Sweden	259794	43463	4674	9995.17	3.85	18568	6.32	0.948	-0.897	0.055	1	-0.928	0
Switzerland	253141	55655	4159	7413.53	2.93	12781	9.66	0.957	-1.165	0.045	1	-1.17	0
United Kingdom	1569712	270380	30323	27984.48	1.78	318825	16.62	0.979	-2.787	0.022	1	-2.821	0
United States	10473725	1965775	152467	275235.80	2.63	650843	12.87	0.999	-4.804	0.001	1	-4.855	0

Note:
GDP, GFKF and Total R&D in thousands, and LF in millions.
Source: Authors’ calculation from the World Bank’s World Development Indicators (WDI).

Table 7 Basic statistic Medium-Low-Tech countries: Mean 2002-2005

Mean 2002-2005	GDP	GFKF	LF	RDTotal	RD % GDP	NBR	NBER	Efficiency TL	mfx TL	Inefficiency TL	Efficiency CD	mfx CD	Inefficiency CD
Algeria	64382	13806	12711	123.24	0.20	12138	14.41	0.933	0.24	0.072	1	0.166	0
Argentina	276607	40192	17813	1180.97	0.42	43500	10.96	0.938	-0.788	0.065	1	-0.864	0
Armenia	2866	710	1298	6.53	0.23	8914	7.65	0.917	3.32	0.09	0.989	3.231	0.011
Bolivia	9221	1290	3966	25.51	0.28	1634	7.37	0.798	2.593	0.245	0.75	2.563	0.309
Botswana	7496	1316	665	28.87	0.39	7549	11.23	0.837	2.771	0.194	1	2.619	0
Chile	86135	19282	6407	580.11	0.67	29044	17.24	0.953	-0.052	0.049	1	-0.129	0
Costa Rica	18032	3309	1854	65.84	0.37	40193	10.82	0.906	1.773	0.104	1	1.662	0
Estonia	7377	2315	666	61.95	0.83	7858	11.86	0.944	2.206	0.059	1	2.066	0
Finland	132214	25261	2634	4535.38	3.43	7343	6.50	0.941	-0.327	0.062	1	-0.367	0
Greece	167682	41299	5020	828.99	0.49	2289	7.20	0.934	-0.842	0.07	1	-0.88	0
Guatemala	21410	3400	3954	6.44	0.03	3924	6.21	0.826	1.683	0.205	0.977	1.602	0.023
Hong Kong, China	187965	44928	3512	1268.25	0.67	59706	11.32	0.955	-0.939	0.047	1	-0.95	0
Hungary	55602	13657	4221	519.82	0.94	21584	9.88	0.953	0.306	0.049	1	0.223	0
India	570124	151914	419498	4058.18	0.71	31435	4.77	0.969	-2.236	0.032	1	-2.348	0
Jordan	10329	2148	1691	34.79	0.34	6028	6.47	0.903	2.214	0.106	1	2.104	0
Kazakhstan	26244	5565	7828	68.46	0.26	2896	9.66	0.916	1.166	0.09	1	1.106	0
Latvia	10194	3128	1120	45.75	0.44	8656	4.80	0.946	1.881	0.056	1	1.76	0
Lithuania	14858	3317	1637	106.41	0.71	3811	5.85	0.913	1.787	0.095	1	1.674	0
Madagascar	4005	756	8243	9.06	0.23	1048	5.92	0.932	2.995	0.073	0.846	3.115	0.182
Mexico	607966	123545	41601	2811.43	0.46	306400	7.14	0.942	-1.971	0.061	1	-2.057	0
Morocco	44488	11747	10682	269.04	0.60	11342	8.24	0.954	0.409	0.048	1	0.335	0
Pakistan	85312	12600	53907	284.58	0.33	2478	5.89	0.87	0.196	0.145	0.965	0.193	0.039
Peru	60307	11074	12573	71.60	0.12	27621	5.39	0.925	0.455	0.081	1	0.387	0
Philippines	87462	14535	35427	123.49	0.14	13328	-	0.912	0.108	0.096	1	0.069	0
Poland	187777	36071	17235	1046.32	0.56	23683	4.79	0.947	-0.72	0.056	1	-0.8	0
Portugal	116059	28018	5498	891.49	0.77	15923	6.17	0.953	-0.437	0.05	1	-0.501	0
Romania	45067	9370	10309	176.37	0.39	76152	10.27	0.937	0.629	0.068	1	0.56	0
Senegal	5420	1312	4507	4.86	0.09	34	3.30	0.996	2.562	0.004	1	2.545	0
Slovak Republic	23562	6248	2666	127.58	0.54	5027	7.09	0.937	1.118	0.067	1	1.019	0
South Africa	150311	24743	19540	1293.88	0.86	33484	6.35	0.942	-0.351	0.062	1	-0.429	0
Spain	648385	177132	19839	6863.20	1.06	128168	6.37	0.969	-2.354	0.032	1	-2.382	0
Sri Lanka	18234	3946	8054	34.21	0.19	3990	7.65	0.911	1.47	0.098	1	1.424	0
Tunisia	22495	5281	3680	192.60	0.85	5757	10.43	0.928	1.261	0.078	1	1.169	0
Turkey	297732	58288	25612	2049.28	0.68	70560	11.66	0.954	-1.191	0.048	1	-1.272	0
Ukraine	41178	8558	22812	435.11	1.06	27670	6.28	0.952	0.649	0.051	1	0.623	0
Zambia	3787	651	4743	0.68	0.02	2815	5.20	0.887	3.18	0.128	0.928	3.233	0.082

Note:

GDP, GFKF and Total R&D in thousands, and LF in millions.

Source: Authors' calculation from the World Bank's World Development Indicators (WDI).